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COMMON TUNA-BAIT FISHES OF THE CENTRAL PACIFIC

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ABSTRACT

The pole-and-line fishery for tunas is dependent upon an adequate supply of live bait for use as chum to attract and hold schools of fish. The present work is designed for the practical field identification of the more common tuna-bait fishes found in the central Pacific region, which for purposes of this report includes the waters surrounding the Hawaiian, northern Line, and Phoenix Island groups. Presented are illustrated keys to the families and species, with descriptions and notes on distribution, and an evaluation of the tuna-bait resources of the central Pacific region with a description of each potential important baiting area. An index of scientific, English, Hawaiian and Gilbertese names of the various fishes considered completes the report.

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Research Report 34.

Common tuna-bait fishes of the central Pacific by Fred C. June & John W. Reintje

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COMMON TUNA-BAIT FISHES OF THE CENTRAL PACIFIC

By FRED C. JUNE and JOHN W. REINTJES

Fishery Research Biologists

RESEARCH REPORT 34

Fish and Wildlife Service, John L. Farley, *Director*

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COMMON TUNA-BAIT FISHES OF THE CENTRAL PACIFIC

For fishermen, and even more for the scientist and the layman concerned with the investigation, exploration, and development of the fishery resources of the Pacific Ocean, the accurate identification of fishes and a knowledge of their distribution, habits, and habitat preferences are of fundamental importance. The studies conducted by the Pacific Oceanic Fishery Investigations of the United States Fish and Wildlife Service on the tunas and other oceanic fishes of the tropical waters of the central Pacific Ocean have shown the need for such knowledge concerning the various species of smaller fishes which offer possibilities as bait for the capture of the larger pelagic forms.

The aim of the present work is to provide means for identifying those groups of smaller fishes which commonly occur in this region and which offer the best possibilities as tuna bait. Based on our present knowledge of the distribution and abundance of the species suitable for use as bait at the various islands in the region, an evaluation of the commercial tuna-fishing possibilities of these bait stocks is given by the senior author in the second part of this paper.

While there are various checklists, artificial keys, and general taxonomic treatises on the fish fauna of the region, because of their formal or technical treatment, these are not of practical use to the untrained observer. Also, most of these works are too comprehensive and detailed to be applied readily and efficiently in the field. This report is intended to be a handbook. It is not an exhaustive treatment of the small-fish fauna represented in the central Pacific region, nor does it attempt any taxonomic revision.

Geographically this report includes the waters of the Hawaiian Islands proper, the Leeward Islands extending from Nihoa to the Midway Islands, Johnston Island, the Line Islands extending from Kingman Reef to Jarvis Island, and the Phoenix Islands (fig. 1). Most of these islands are of volcanic origin. Some protrude above the surface to a height of over 13,000 feet, and most are surrounded by fringing coral reefs which extend only a short distance offshore. In others, the volcanic cones do not reach the surface, but are capped with coral growth to form coral islands, which sometimes form atolls enclosing a central lagoon. The largest such lagoon is found at

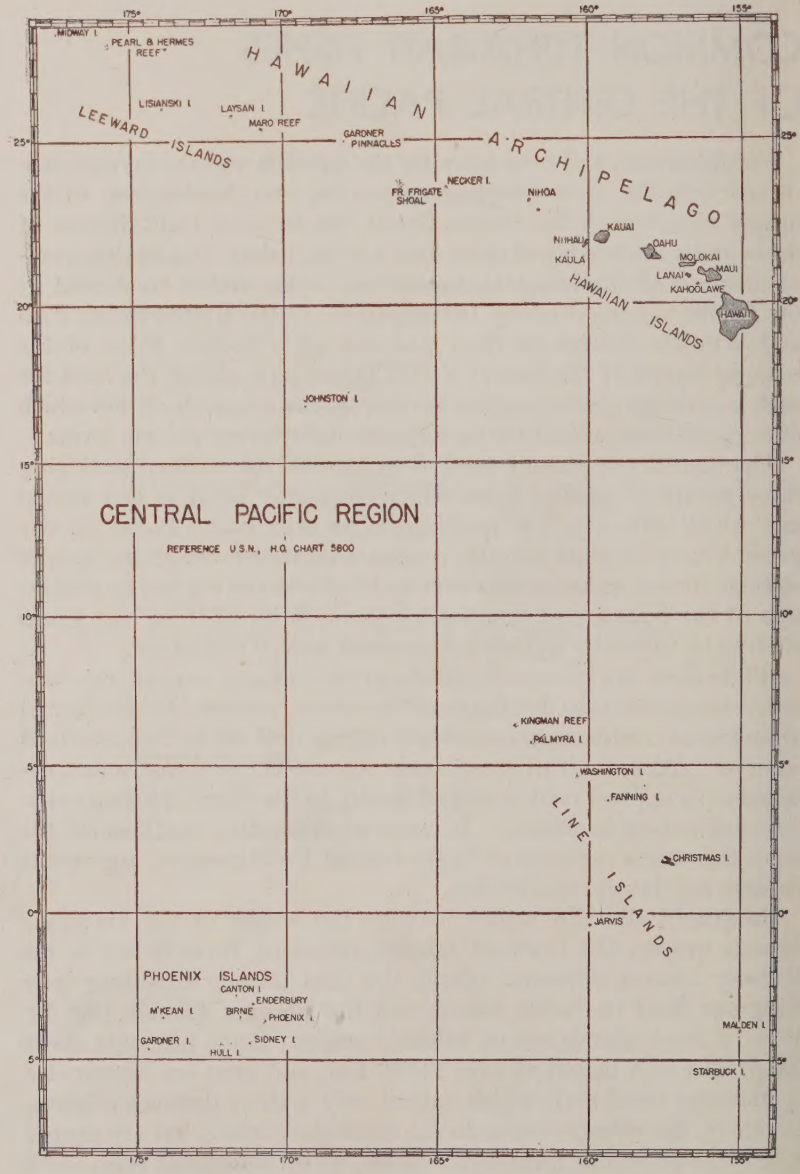

Figure 1.—Map of the region covered by this report.

Christmas Island and measures about 12 miles in length and 8 miles in width, occupying most of the western third of the island.

The waters of the central Pacific Ocean contain an extensive fish fauna which includes representatives of the most important families of tropical marine fishes. Although nearer to the Americas than to any other large land mass, there are very few shore and reef fishes in the central Pacific Islands which are found also in the Americas. On the other hand, there are many central Pacific species which are found also in the Indian Ocean and the East Indies or have near relatives there. The East Indian fauna appears to be the original center from which many forms were distributed eastward throughout Polynesia and northward to Hawaii. The Hawaiian Islands proper constitute the northeastern limit for many species. In addition to the fishes which occur both in the Hawaiian Archipelago and in the East Indies, there are some species found only in Hawaii.

Most of our present knowledge of the distribution of these forms comes from the scientific expeditions, which made extensive collections at the various islands and reef areas within this region. Among these were the following: the United States Exploring Expedition in 1840; the *Challenger* Expedition in 1875; the expedition of the United States Fish Commission in 1901, including the work of the *Albatross* in 1902; the *Tanager* Expedition in 1923; and the United States Navy Surveying Expedition to the Phoenix and Samoan Islands in 1939. Most of the collections of these fishes are to be found in the United States National Museum, Washington, D. C., and in the Bernice P. Bishop Museum, Honolulu, Hawaii.

Fowler (1928, 1931, 1934, and 1949) provided a wealth of information on distribution. In addition, Weber and De Beaufort (1913, 1922, 1929, and 1931), Jordan and Evermann (1905), Schultz (1943), and Brock (1950) have been consulted.

Extensive collections have been made by vessels of the United States Fish and Wildlife Service throughout this region, and new distribution records have been included and older records verified.

An index of scientific, English, Hawaiian, and Gilbertese names of the various fishes has been included.

Keys and Descriptions of Families and Species of Bait Fishes

We have attempted to devise simple and concise keys for both the family groups and the species without undue compromise of the means for identification. The subtle intergeneric and interspecific differences, as well as the intergrades between subspecies within and between island faunal groups have purposely been ignored. These

intergrades occur to a certain extent and may be recognized as intermediate between the described forms. The keys presented are designed to serve as a guide in identifying the common bait fishes and are artificial in that they do not present a complete systematic arrangement of the families.

The keys are constructed on an "either—or" basis. Either the first of the alternative statements in the key applies to the specimen, or the second statement applies. If the first statement is correct, the identification may be completed, or the next alternative statements are taken and so on until a name given at the end of the line fits the fish. On the other hand, if the first statement does not apply, the alternative statement indicated by the number at the end of the line must apply. The number with its alternative statements then is located and the "either—or" process continued until the identification has been completed.

The following procedure should be followed in identifying an individual specimen:

1. Determine the family to which the fish belongs in the Key to the Families;
2. Determine the fish under the family in the Key to the Species;
3. Make certain of the identification by checking the specimen against the illustration and verifying that the geographic distribution given for each species includes the area from which the specimen came.

The notes on habitats are general and oversimplified, and the notes on distribution should not be assumed to be complete for the various bait species reported.

A partial synonymy, or list of other scientific names of a fish given by various authors, is included following the scientific name of the species. While the synonymies are not complete, they include the original descriptions, references to the more extensive synonymies, and certain principal notes on distribution.

The Hawaiian names of fishes are used more generally throughout the central Pacific region than are any others. Where applicable they are included with the scientific or common English name.

In the description of fishes certain general anatomical and other technical terms are used. The following list, or glossary, is given to assist in using the keys, and figures 2 and 3 illustrate some of the terms defined in it.

Glossary of Terms

ADIPOSE EYELID.—A fatty, immovable lid or sheath which often covers most of the eye.

ADIPOSE FIN.—A soft fin without rays or spines along midline of back behind dorsal fins.

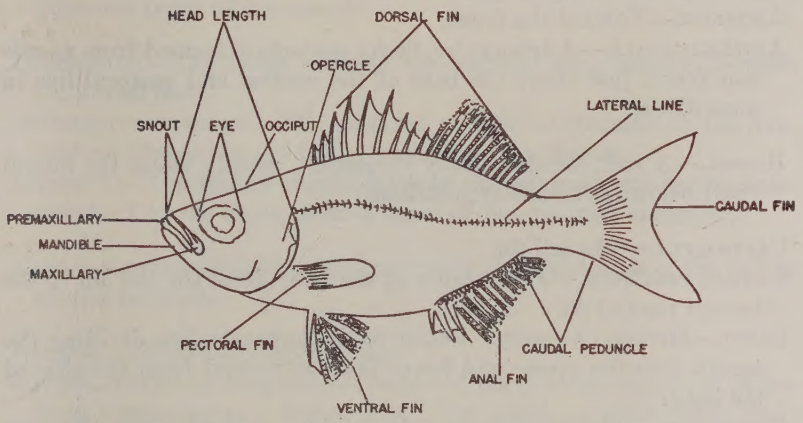

Figure 2.—Sketch of a typical fish illustrating terms defined in the glossary.

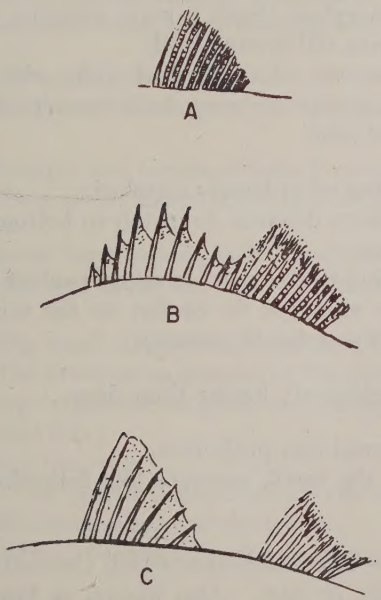

Figure 3.—Three types of dorsal fins: A, single soft dorsal; B, single dorsal differentiated into an anterior spiny and a posterior soft portion; C, two separate dorsal fins, the anterior one with spines and the posterior one with soft rays.

ANAL FIN.—The unpaired fin that lies along the midline on the ventral surface of the body behind the anus.

ANTERIOR.—Toward the front.

AXILLARY SCALE.—A triangular, fleshy projection formed from a scale and found just above the base of the ventral and pectoral fins in some fishes.

BARBEL.—A soft, slender, fleshy projection, usually about the mouth (pair below the mouth in goatfishes).

CAUDAL FIN.—The tail fin.

CAUDAL PEDUNCLE.—That region of the body from the last fin to the base of the tail fin.

CLEFT.—Division or split. Refers to the apparent line dividing the mouth into the upper and lower jaws as viewed from the side of the head.

COMPRESSED.—Flattened from side to side; said of fishes that are deeper than broad.

CTENOID.—With rough edges; said of scales with spinous or comb-like posterior margins. Such a scale covering feels rough when fish is stroked from tail toward head.

CYCLOID.—With smooth edges; said of scales with smooth posterior margins. Such a scale covering feels smooth when fish is stroked from tail toward head.

DECIDUOUS.—Falling off or loosely attached.

DEPTH.—The greatest distance from top to bottom of the body, exclusive of the fins.

DORSAL.—Pertaining to the back or upper part of the body.

DORSAL FIN.—The unpaired fin or fins on the midline of the back (excludes the adipose fin, if present).

ELONGATED.—Lengthened; longer than deep.

FILAMENT.—A thread-like projection.

FINLET.—One of the small, separate fins following the dorsal and anal fins.

GILL MEMBRANES.—The membranes which close off the lower part of the gill chamber, in part. Also known as branchiostegal membrane. The gill membranes may be connected to each other across the isthmus or they may be separated. They may be attached laterally or ventrally to the isthmus or free from it.

GILL OPENING.—The external opening, under or behind the head, leading from the gills.

HEAD LENGTH.—The distance from the tip of the snout to the most posterior point of the opercle.

INTERSPACE.—The space between the vertical fins, usually between the dorsal fins.

INTROMITTENT ORGAN.—The modified anal fin of the male in the livebearers adapted to guide the sperm into the female.

ISTHMUS.—The narrow region between the gill openings on the anterior part of the chest, usually more or less pointed anteriorly.

KEEL.—A ridge extending longitudinally along the sides of the tail or caudal peduncle.

LATERAL.—Pertaining to the sides.

LATERAL LINE.—A longitudinal series of pores along each side of the body appearing as a dotted line. Not visible in some fishes, multiple in others.

MANDIBLE.—The main bone forming the lower jaw.

MAXILLARIES.—The outer main bones forming the upper jaw.

OBSOLETE.—Scarcely evident or absent.

OCCIPITAL.—Pertaining to the occiput; the hindmost bone on top of the head.

OPERCLE.—The principal and hindmost bone forming the gill cover.

ORIGIN OF FIN.—The anterior end of the base of a fin.

PALATINES.—A pair of bones, one on each side of the roof of the mouth extending outward and backward from the vomer, sometimes bearing teeth.

PAPILLOSE.—Bearing small fingerlike projections or frills.

PECTORAL FINS.—The front or uppermost of the paired fins.

PELVIC.—Pertaining to the pelvic girdle or the region of the pelvic fins. (*See* Ventral fins.)

POSTERIOR.—Toward the rear.

PREMAXILLARIES.—The paired bones forming the front of the upper jaw and generally bearing most of the teeth.

PROTRACTILE.—Capable of being extended forward, e. g., the premaxillary bones.

PSEUDOBRANCH.—Small partial gill on inside of opercle near base of skull.

PTERYGOIDS.—A pair of bones, one on each side of the roof of the mouth, behind the palatines, sometimes bearing teeth.

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Rays.—The segmented, usually flexible, rods supporting the fin membranes; sometimes branched.

Scute.—An external bony or horny plate.

Snout.—The part of the head which projects in front of the eyes.

Soft dorsal.—The hind part of a dorsal fin which is supported by rays.

Spines.—The unsegmented, usually pointed, rods supporting the fin membranes.

Spinous dorsal.—The anterior part of the dorsal fin which is supported by spines.

Standard length.—The distance from the most anterior part of the head (whether the upper or lower jaw projects) backward to the end of the vertebral column (structural base of the caudal fin rays). Abbreviated s. l.

Subterminal.—Said of the mouth when it lies behind and below the snout.

Symphysial knob.—A projection or bulge at the point of junction of the lower jaw bones.

Symphysis.—The tip of the chin; the point of juncture of the two parts of the lower jaw.

Synonymy.—A list of the technical names that have been given to a genus or a species.

Tail.—That portion of the body posterior to the anal fin; in most fishes this is applied to caudal peduncle and caudal fin, inclusive.

Terminal.—At the end. Said of the mouth when it is at the anterior end of the head.

Thoracic.—In the region of the thorax or chest. Said of the ventral fins when they are attached more or less below the pectoral fins.

Total length.—The greatest straight-line distance between the most anteriorly projecting part of the head and the tip of the caudal fin when the caudal fin rays are squeezed together. Abbeviated t. l.

Truncate.—With the end cut square or even.

Ventral.—Pertaining to the lower surface of the body.

Ventral fins.—The paired fins located below or behind the pectoral fins.

Vertical fins.—Fins located on the midline of the body as the dorsal, anal, and caudal.

Vomer.—A bone in the front part of the roof of the mouth, lying immediately behind the premaxillaries.

Key to the Families

1. Caudal fin rounded; anal fin of the male unlike that of the female, modified into an intromittent organ

Family POECILIIDAE
Top minnows
Page 17

Caudal fin not rounded; anal fin of the male like that of the female 2

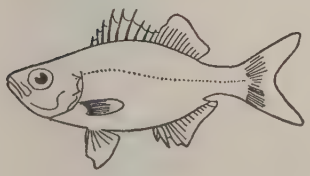
2. Single dorsal fin (fin may consist of anterior spinous part and posterior soft part (fig. 3) 3
Two dorsal fins 7

3. Teeth absent; small symphysial tubercle present on lower jaw

Family CHANIDAE
Milkfish
Page 13

Teeth present; no symphysial tubercle on lower jaw 4

4. Single dorsal fin deeply notched and consisting of anterior spines and posterior soft rays; opercle with 2 flat spines on posterior margin



Family KUHLIIDAE
Mountain basses
Page 31

Single dorsal fin consisting of soft rays only; no spines on opercle 5

5. Eye almost completely covered with an adipose lid; lateral line present; membrane of first dorsal fin covered with small scales

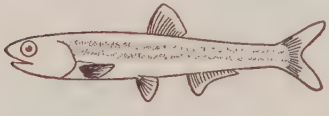
Family ALBULIDAE
Bonefishes
Page 11

Adipose eyelid absent; lateral line absent; no scales present on membrane of first dorsal fin---------- 6

6. Mouth terminal; jaws about equal; a fleshy appendage at the base of ventral fins

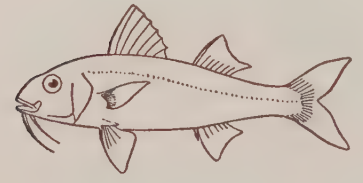
Family DUSSUMIERIIDAE
Round herrings
Page 14

Mouth very large, more or less oblique with an overhanging snout; no fleshy appendage at base of ventral fins



Family ENGRAULIDAE
Anchovies
Page 16

7. Two long branched barbels present on throat (attached behind symphysis of lower jaw)



Family MULLIDAE
Goatfishes
Page 33

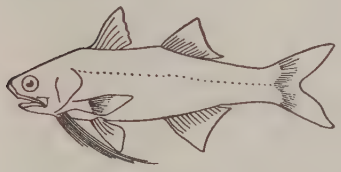
No barbels present on lower jaw---------- 8

8. Broad, silvery lateral band along sides of body (sometimes underlaid with black pigment); first dorsal with 5 or 6 spines

Family ATHERINIDAE
Silversides
Page 19

No lateral band along sides of body---------- 9

9. Pectoral fins in 2 parts, the lower (anterior) part filamentous; first dorsal with 7 spines



Family POLYNEMIDAE
Threadfins
Page 26

Pectoral fins entire 10

10. First dorsal fin with 4 stiff spines; anal fin with 2 or 3 graduated spines

Family MUGILIDAE
Mullets
Page 21

First dorsal spines weak; 2 stiff spines in front of and separate from anal fin

Family CARANGIDAE
Jacks
Page 28

Bonefishes or ladyfishes—Family ALBULIDAE

The bonefish has an elongated, slightly compressed body covered with small, silvery scales. There is a single, soft dorsal fin, its membranes covered with small scales. The caudal fin is deeply forked with the lobes equal. The piglike snout overhangs the small, horizontal mouth. Teeth are present on both jaws, vomer, and palatines; tongue, roof, and floor of the mouth have patches of blunt, coarse teeth. The eye is almost completely covered with an adipose lid. The lateral line is straight and well developed. In life, the bonefish is bluish above and bright silvery on the sides and belly, with faint, dark lines between the rows of scales. The margins of the caudal and dorsal fins are dusky. The bonefishes are widely distributed and known from all tropical seas.

During development, the bonefish passes through a series of changes similar to that of eels and certain other soft-rayed fishes. In the larval stage, bonefish are flat, ribbon-shaped, translucent organisms

known as leptocephali. They are reported to reduce in length from about 3 inches to less than 2 inches while undergoing the change from the larval stage to that of the adult (Meek and Hildebrand 1923). With reference to their feeding habits, Fitch (1950) states:

> In waters where they are abundant, small bonefish usually form schools, and can be located on a tidal flat by the trail of muddy water left in their wake as they grub in the bottom with their projecting conic snouts for molluscs and crustaceans. * * * Many times the water is so shallow that their tails extend above the surface as they bury their noses in the soft mud.

The same author also claims that the adults have the "same general feeding habits, but tend to be solitary in their movements or at most travel in groups of but a few individuals." They attain a maximum size of about 40 inches.

BONEFISH, *Albula vulpes* (Linnaeus). Fig. 4.

Figure 4.—*Albula vulpes*, bonefish; oio (Hawaiian); te ikari (Gilbertese).

Local names: Oio (Hawaiian); te ikari (Gilbertese).

Synonymy:

Esox vulpes Linnaeus: Systema Nat., 10th ed., p. 313, 1758 (original description).

Albula vulpes Jordan and Evermann: U. S. Fish Comm., Bull., vol. 23, pt. 1, p. 55, 1905 (synonymy, description). Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 27, 1928 (synonymy, distribution).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 55; Fowler, 1938, p. 263, 1940a, p. 743, 1940b, p. 529). In the Leeward Islands from Lisianski (Fowler and Ball, 1925, p. 5) and French Frigate Shoal (1 specimen, U. H. cat. No. 880, 319 mm. s. l.). In the Line Islands from Fanning (Ross, 1947, p. 36), Christmas (Fowler, 1927, p. 5, 1938, p. 188), and Palmyra, from specimens examined by the authors in June 1949 and April 1951. In the Phoenix Islands from Canton (Schultz, 1943, p. 7; 1 specimen, POFI [1] cat. No. 21, 74 mm. t.l.; 1 specimen, U. H. cat. No. 1036, 235 mm. s. l.).

[1] The abbreviations POFI, for Pacific Oceanic Fishery Investigation, and U. H., for the University of Hawaii, are used throughout the notes on distribution.

Importance:

Small bonefish are excellent bait for pole-and-line fishing. They frequently are encountered in schools along sandy shores, and often are taken in the nets during seining operations for other bait species.

Milkfish—Family CHANIDAE

In this family the body is oblong and compressed. The snout is flattened; the terminal mouth is small and toothless. The gill membranes are broadly united. An axillary scale is present on both the ventral and pectoral fins. The lateral line is complete. The single, soft dorsal fin is situated slightly forward of the ventral fins. Scales are small, silvery, adherent, and longitudinally striped. An adipose lid completely covers the eye. The caudal fin is long and deeply forked. In life, the milkfish is greenish gray above, with bright silvery sides and belly. The margins of the dorsal, caudal, and anal fins are dusky. There is only one living member of the family, which occurs generally throughout the tropical Indo-Pacific region.

The milkfish is a highly esteemed food fish over most of its range. In certain far-eastern countries, such as the Philippines and Indonesia, fish culture has made it one of the most important and popular food fishes. Small milkfish at times are encountered in schools on the reefs or on sandy beaches near shore. Carbine (1948) reports that in the Philippines, where it is called bangos, this species is a "fish of the open sea * * * the adults * * * seldom enter shallow water except during the spawning season." The author continues, "bangos from 10 to 13 millimeters in length (0.4 to 0.5 inch) are found near shore. They enter estuaries and tidal streams during the advancing flood tide." It reaches a maximum length of about 6 feet.

MILKFISH, *Chanos chanos* (Forskål). Fig. 5.

Local names: Awa (Hawaiian); te baneawa (Gilbertese).

Synonymy:

Mugil chanos Forskål: Description Animalium, pp. 14 and 74, 1775 (original description).

Chanos chanos Jordan and Evermann: U. S. Fish Comm., Bull., vol. 23, pt. 1, p. 56, 1905 (synonymy, description). Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 28, 1928 (synonymy, distribution).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 57; Fowler, 1925, p. 23, 1928, p. 28). No record from the Leeward Islands or Johnston Island. In the Line Islands from Palmyra (Fowler, 1938, p.

Figure 5.—*Chanos chanos*, milkfish; awa (Hawaiian); te baneawa (Gilbertese).

212), Fanning (Fowler, 1927, p. 5, 1938, p. 264), and Christmas (Fowler, 1927, p. 5, 1938, p. 188). In the Phoenix Islands from Canton (2 specimens, POFI cat. Nos. 1432 and 1433, 160–175 mm. t.l.).

Importance:

When obtainable, small milkfish are suitable as live bait. They often are captured in the nets during seining operations for other bait species.

Round herrings—Family DUSSUMIERIIDAE

Members of the round herring family have an elongated body; the belly is rounded, or compressed, and without scutes or spines. The lateral line is absent; the scales are large, cycloid, and deciduous. There is a single dorsal fin situated about midlength of the body and slightly forward of the ventral fins. A fleshy flap occurs at the base of each pelvic fin. The mouth is rather small and terminal, with the jaws about equal. Small teeth are present on the jaws, vomer, palatines, pterygoids, and tongue.

These are rather small, silvery fishes that usually swim in schools over sandy beaches. Members of the family occur throughout most of the Indo-Pacific tropics, however, only two species are represented in the fauna of the central Pacific region. In the Philippines and other far-eastern countries, the flesh of these fishes is much in demand for savory pastes and condiments.

KEY TO THE SPECIES

Thick, gelatinous, adipose lid, or sheath, covering the eye; dorsal fin with 19–20 soft rays----------
PACIFIC ROUND HERRING (*Etrumeus micropus*)

No adipose lid or sheath covering the eye; dorsal fin with 9–10 soft rays----------
SMALL ROUND HERRING (*Spratelloides delicatulus*)

PACIFIC ROUND HERRING, *Etrumeus micropus* (Schlegel). Fig. 6.

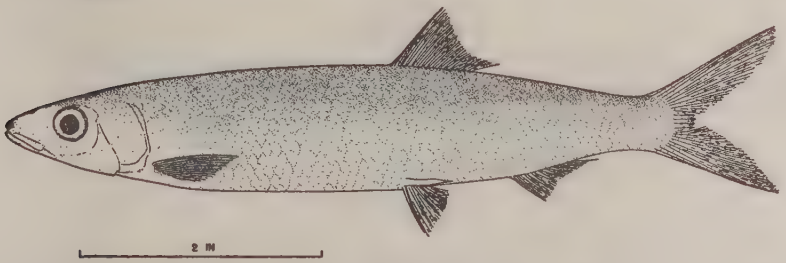


Figure 6.—*Etrumeus micropus*, Pacific round herring; makiawa (Hawaiian); te tarabuti? (Gilbertese).

Local names: Makiawa (Hawaiian); te tarabuti? (Gilbertese).

Synonymy:

Clupea micropus Schlegel: Fauna Japonica, Poiss., pts. 10–14, p. 236, 1846 (original description).

Etrumeus micropus Jordan and Evermann: U. S. Fish Comm., Bull., vol. 23, pt. 1, p. 58, 1905 (synonymy, distribution).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 58, 1926, p. 5; Fowler, 1928, p. 29, 1938, p. 264). In the Line Islands from Christmas (7 specimens, POFI cat. Nos. 215, 727, and 728, 117–164 mm. t.l.) and Palmyra (10 specimens, POFI cat. Nos. 729, 737, and 738, 28–78 mm. t.l.).

Importance:

In the Hawaiian Islands, the Pacific round herring, when obtainable, is used for live bait in the pole-and-line fishery for skipjack, or aku (*Katsuwonus pelamis*); however, it apparently does not occur in any great numbers in the region.

SMALL ROUND HERRING, *Spratelloides delicatulus* (Bennett). Fig. 7.

Local names: Piha (Hawaiian); te tukurora? (Gilbertese).

Synonymy:

Clupea delicatula Bennett: Comm. Zool. Soc. London, Proc., vol. 1, p. 168, 1831 (original description).

Stolephorus delicatulus Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 29, 1928 (synonymy, distribution).

Spratelloides delicatulus Schultz: U. S. Natl. Mus., Bull. 180, p. 10, 1943 (synonymy, list of specimens).

Distribution:

Reported from the Hawaiian Islands (Fowler, 1928, p. 29, 1938, p. 264). In the Leeward Islands from Lisianski, Pearl and Hermes Reef, and

Figure 7.—*Spratelloides delicatulus*, small round herring; piha (Hawaiian); te tukurora? (Gilbertese).

French Frigate Shoal (Fowler and Ball, 1925, p. 5; Pietschmann, 1938, p. 9), and Midway Islands (35 specimens, POFI cat. Nos. 258 and 266, 29–60 mm. t.l.). In the Phoenix Islands from Canton (Schultz, 1943, p. 10; 3 specimens, POFI cat. No. 251, 41–43 mm. t.l.) and Hull (Schultz, 1943, p. 10).

Importance:

The small round herring is an excellent live-bait species for pole-and-line fishing. It is very delicate, and unless handled carefully will not survive for more than a few days in the bait tank. It is one of the more common species in the Leeward Islands, and occurs most abundantly at Pearl and Hermes Reef and Midway Islands. This species is most readily captured by means of a lift net, together with a submarine light which is set out at night to attract the fish.

Anchovies—Family ENGRAULIDAE

In the anchovies, the body is elongated, somewhat compressed, and covered with large, thin, cycloid scales. The lateral line is absent, but many members of the family have a bright silvery-white lateral band. The maxillaries are very long and slender; the mouth is extremely large and more or less oblique; the snout is rounded and overlaps the mouth. Small teeth are present in a single row on both jaws and usually on the vomer, palatines, and pterygoids. There is a single dorsal fin.

The anchovies are small, delicate, more or less translucent fishes which occur mainly in tropical seas; some also enter fresh water. They often occur in large schools along sandy shores (Jordan and Evermann 1905, Fowler 1940 b). Only one species comes within the scope of the present work. The flesh is dark in color and is often used as a condiment.

HAWAIIAN ANCHOVY, *Stolephorus purpureus* Fowler. Fig. 8.

Figure 8.—*Stolephorus purpureus*, Hawaiian anchovy; nehu (Hawaiian); te neia? (Gilbertese).

Local names: Nehu (Hawaiian); te neia? (Gilbertese).

Synonymy:

Stolephorus purpureus Fowler: Acad. Nat. Sci. Phila., Proc., p. 497, 1900 (original description). Gosline: Pacific Sci., vol. 5, No. 3, p. 272, 1951 (reassignment to original genus).

Anchovia purpurea Jordan and Evermann: U. S. Fish Comm., Bull. vol. 23, pt. 1, p. 60, 1905 (synonymy, description, distribution).

Engraulis purpureus Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 33, 1928 (synonymy, distribution).

Anchoviella purpurea Fowler: B. P. Bishop Mus., Mem., vol. 11, pt. 6, p. 387, 1934 (synonymy).

Distribution:

A single species reported only from the Hawaiian Islands (Fowler, 1928, p. 33, 1938, p. 264; Pietschmann, 1938, p. 10).

Importance:

It is the single most-important bait species used in the pole-and-line fishery for skipjack in the Hawaiian Islands. In addition to its good survival qualities in the bait wells of the sampans, it characteristically "schools up" close to the boat when scattered as chum.

Top minnows or killifishes—Family POECILIIDAE

Members of this family are small, often brightly colored fishes that bear living young. The body is oblong and more or less rounded; the lateral line is absent. There is a single dorsal fin, which in the males is often elongated into a bannerlike appendage. The adult males are also marked by the conspicuously elongated anal fin which is used as an intromittent organ to guide the sperm into the female. The caudal

fin is rounded. The mouth slants upward, and the premaxillaries are protractile (separated from the snout by a groove); the maxillaries are distinct. The gill membranes are free from the isthmus. The males, generally, are smaller than the females.

This family of fishes is exclusively American (Hubbs and Lagler 1947); however, in recent times various species have become established in many parts of the world. The top minnows are most renowned for their part in the control of mosquitoes. Their surface-feeding habits make them particularly valuable for this purpose. The mosquito larvae suspend themselves at the surface of the water to breathe and become easy prey for the top minnows, which are commonly called mosquito fish. Various species in the family also are popular aquarium fishes. A single species, *Mollienesia latipinna*, comes within the scope of the present work. Other species of top minnows have been introduced successfully into the fresh and brackish waters of the island of Oahu; however, *M. latipinna* is the most common and the most important as a bait species. *Mollienesia sphenops* (Valenciennes) and *Limia vittata* (Guichenot) occupy the same habitats as *M. latipinna* and occasionaly are caught in the nets during seining operations for this species. *M. latipinna* may be distinguished from *M. sphenops* and *L. vittata* by the dorsal fin-ray counts, the former having 13 or more rays and the latter two species having a count of 10 or fewer dorsal rays.

SAILFIN MOLLY, *Mollienesia latipinna* LeSueur. Fig. 9.

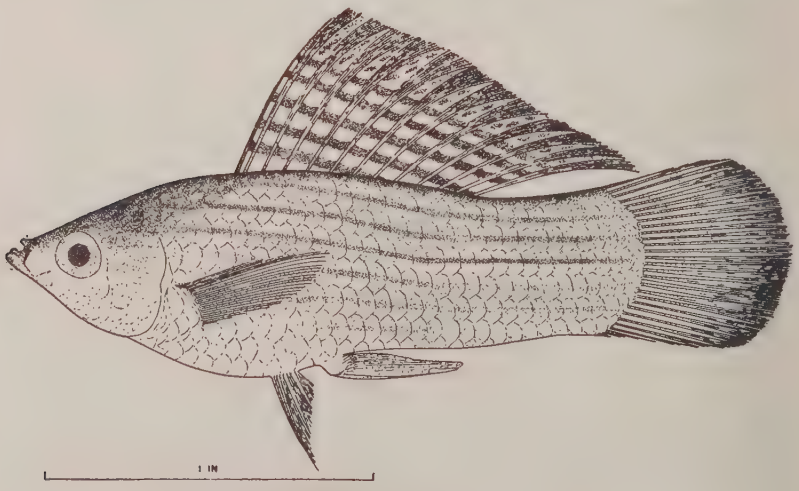


Figure 9.—*Mollienesia latipinna*, sailfin molly.

Local names: None known.

Synonymy:

Mollinesia latipinna LeSueur, Acad. Nat. Sci. Phila., Jour., vol. 2, p. 3, 1821 (original description, typographical error in generic name). Bailey and Miller (1950) refer to the frequent misspelling of this genus and suggest the use of *Mollienesia*. Fowler, Acad. Nat. Sci. Phila., Proc., vol. 93, p. 248, 1941 (distribution).

Distribution:

Reported from the Hawaiian Islands (Fowler, 1938, p. 217, 1941, p. 248; Tinker, 1944, p. 88; 310 specimens, POFI cat. Nos. 630, 633, 634, and 635, 30–60 mm. t.l.). There are no reports of the successful introduction of members of the family in the Leeward, Line, or Phoenix Islands.

Importance:

In the Hawaiian Islands, sailfin molly often is used for live bait in the pole-and-line fishery for skipjack, and it becomes especially important at times when other bait species are scarce.

Silversides—Family ATHERINIDAE

The silversides are small, streamlined fishes which generally are found close to shore. There are two dorsal fins, which are well separated (the first dorsal may escape notice unless carefully looked for); the first dorsal has 4 to 8 flexible spines. The scales are very thin and deciduous. There is no lateral line, but most species in the family have a silvery band along the sides of the body which may be underlaid with black pigment. The mouth is more or less oblique and terminal.

Most members of the family are marine, but many species inhabit fresh water. They are of worldwide distribution and occur mostly in tropical waters (Schultz 1948). Jordan and Hubbs (1919) state:

None are known from the depth of the ocean; they are confined everywhere to the surface and the shoreline. The species are usually small, the tropical ones almost uniformly so, attaining a length from three to six inches.

Only two species come within the scope of the present work. The two genera of silversides common in this region possess no striking characters for simple field identification; however, a posterior branch of the mandible is distinctly elevated in *Allanetta*, whereas in *Pranesus* this branch is only slightly elevated (Schultz 1948). In many countries the silversides are prized as food; also, they serve as food for many commercially important fishes and for many species of oceanic birds.

HAWAIIAN SILVERSIDES, *Pranesus insularum* (Jordan and Evermann). Fig. 10.

Figure 10.—*Pranesus insularum*, Hawaiian silversides; iao (Hawaiian); te kawarek? (Gilbertese).

Local names: Iao (Hawaiian); te kawarek? (Gilbertese).

Synonymy:

Atherina insularum Jordan and Evermann: U. S. Fish Comm., Bull., vol. 22, p. 170, 1903 (original description).

Hepsetia insularum Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 119, 1928 (synonymy, distribution).

Thoracatherina insularum Fowler: Acad. Nat. Sci. Phila., Proc., vol. 93 p. 249, 1941 (new genus).

Pranesus insularum Schultz: U. S. Natl. Mus., Proc., vol. 98, p. 23, 1948 (synonymy).

Distribution:

Reported from the Hawaiian Islands (Fowler, 1928, p. 119, 1938, p. 275). In the Leeward Islands from Lisianski (Fowler and Ball, 1925, p. 10), Pearl and Hermes Reef, French Frigate Shoal (Galtsoff, 1933, p. 20; Pietschmann, 1938, p. 15), and Midway Islands (73 specimens, POFI cat. Nos. 57, 74, and 99, 37–103 mm. t. l.). In the Line Islands from Christmas (7 specimens, POFI cat. Nos. 45, 48, and 85, 22–97 mm. t.l.).

Importance:

In the Hawaiian Islands, this species of silversides is the second most-important bait fish used in the pole-and-line fishery for skipjack. It is probably the best bait fish found in the Leeward Islands; however, apparent fluctuations in the abundance of the stocks at the various islands in the chain make it an unreliable species for capture. It is a hardy fish and if properly handled, is suitable for long-distance transportation in bait tanks.

FIJIAN SILVERSIDES, *Allanetta ovalaua* (Herre). Fig. 11.

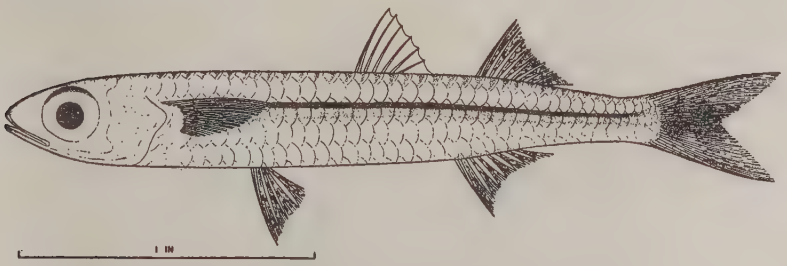


Figure 11.—*Allanetta ovalaua*, Fijian silversides; te kawarek? (Gilbertese).

Local name: Te kawarek? (Gilbertese).

Synonymy:

Atherina ovalaua Herre: Field Mus. Nat. Hist. Publ., zool. ser., vol. 18, p. 401, 1935 (original description).

Allanetta ovalaua Schultz: U. S. Natl. Mus., Proc., vol. 98, p. 22, 1948 (synonymy).

Distribution:

In the Phoenix Islands from Canton (Schultz, 1943, p. 78; 10 specimens, POFI cat. Nos. 47, 62, and 67, 48–62 mm. t.l.; 1 specimen, U. H. cat. No. 996, 38 mm. s. l.); from Hull (Schultz 1943, p. 78; 39 specimens, U. H. cat. No. 1122, 43–60 mm. s. l.).

Importance:

This species of silversides is a hardy live-bait fish which, apparently, occurs in this region only in the Phoenix Islands. It never has been caught in great quantities, although large schools have been observed along the sandy beaches inside the lagoons at both Canton and Hull Islands.

Mullets—Family MUGILIDAE

The bodies of the mullets are oblong and somewhat compressed. The head is rather blunt and scaled above and on the sides. The lateral line is obsolete, but lateral scales commonly have furrows or pits which form lateral streaks. The premaxillaries are protractile. The mouth is small, and the teeth are very small or wanting. There are two dorsal fins, which are well separated; the first dorsal has 4 stiff spines and the second dorsal 1 spine and 5 soft rays. The anal fin has 3 weak spines and 5 rays. The gill openings are wide, with the gill membranes separate and free from the isthmus.

The mullets are widely distributed in all warm seas of the world and occur in both marine and fresh water. All of the marine genera have cycloid scales, except one (*Chaenomugil*), which has ctenoid scales. They are bottom-feeding fishes that travel in schools along the shores, reefs, and in the lagoons of most coral islands; some enter estuaries and shallow bays, and some enter or inhabit fresh water. Smith (1950) states, "The Mugilidae feed mainly on minute plants, eggs, and the young of marine creatures. They nibble at marine growth, or scoop up mud and slime, and after sucking out the edible portion reject the hard residue." Often schools of these fishes may be seen jumping over the surface of the water; however, some authors claim that this phenomenon is characteristic of only certain species (Smith 1950). Most of the species in this group are rather small, although some are reported to reach a weight of over 20 pounds.

In many tropical countries the mullets are important food fishes. In Hawaii one species in particular (*Mugil cephalus*) has been reared in ponds for centuries, and even today it is economically important in the islands.

English names, hitherto lacking, have been supplied for three of the species treated in this paper—*Mugil vaigiensis*, *M. longimanus*, and *Crenimugil crenilabis*.

KEY TO THE SPECIES

1. Cleft of mouth oblique; snout and lower jaw pointed; no adipose eyelid--- FALSE MULLET (*Neomyxus chaptalii*)
   Cleft of mouth horizontal; snout and lower jaw blunt and rounded; adipose eyelid more or less developed---------- 2
2. Upper half of pectoral fins black; caudal fin truncate; 25–27 scales in lateral series----------
   BLACK-FIN MULLET (*Mugil vaigiensis*)
   Upper half of pectoral fins not black, may have small spot at base; caudal fin forked; more than 30 scales in lateral series---------- 3
3. Lips smooth, without fleshy projections or teeth; 31–34 scales in lateral series----------
   BLUE-TAIL MULLET (*Mugil longimanus*)
   Lips with teeth or fleshy projections; 37–40 scales in lateral series---------- 4
4. Single row of yellow teeth on lips, no fleshy projections on upper lip; adipose eyelid well developed----------
   STRIPED MULLET (*Mugil cephalus*)
   No teeth on lips, papillose fringe of fleshy projections on thick upper lip; adipose eyelid minute----------
   THICK-LIP MULLET (*Crenimugil crenilabis*)

FALSE MULLET, *Neomyxus chaptalii* (Eydoux and Souleyet). Fig. 12.

Figure 12.—*Neomyxus chaptalii*, false mullet; uouoa (Hawaiian).

Local name: Uouoa (Hawaiian).

Synonymy:

Mugil chaptalii Eydoux and Souleyet: Voyage *Bonite*, Zool., vol. 1, p. 171, 1841 (original description).

Chaenomugil chaptalii Jordan and Evermann: U. S. Fish Comm., Bull., vol. 23, pt. 1, p. 140, 1905 (distribution, synonymy).

Myxus pacificus Pietschmann: B. P. Bishop Mus., Bull. 156, p. 16, 1938 (list of specimens). Fowler: B. P. Bishop Mus., Mem., vol. 12, No. 2, p. 72, 1949 (synonymy).

Neomyxus chaptalii Schultz: U. S. Natl. Mus., Bull. 180, p. 80, 1943 (synonymy, list of specimens).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 140; Fowler, 1928, p. 127, 1938, p. 276). In the Leeward Islands from French Frigate Shoal (Fowler and Ball, 1925, p. 11; Fowler, 1928, p. 127; 1 specimen, POFI cat. No. 537, 70 mm. t. l.), Laysan (Fowler and Ball, 1925, p. 11; Fowler, 1928, p. 127; 1 specimen, U. H. cat. No. 1071, 270 mm. s. l.), and Lisianski (Fowler and Ball, 1925, p. 11). In the Line Islands from Palmyra (Fowler, 1927, p. 10; 1 specimen, POFI cat. No. 518, 42 mm. t. l.), Washington (Fowler, 1927, p. 10), and Christmas (Fowler, 1927, p. 10, 1938, p. 195). In the Phoenix Islands from Canton (specimens examined by the authors in February 1950), Enderbury (Schultz, 1943, p. 80), and Hull (Schultz, 1943, p. 80; 1 specimen, U. H. cat. No. 1121, 47 mm. s. l.).

Importance:

False mullet often is caught in the nets during seining operations for other bait fishes. This species appears to occur most abundantly in the Leeward Islands. A fair bait fish for pole-and-line fishing.

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BLACK-FIN MULLET, *Mugil vaigiensis* Quoy and Gaimard. Fig. 13.

Figure 13.—*Mugil vaigiensis*, black-fin mullet; te bai taba, te aua taba (Gilbertese).

Local names: Te bai taba, te aua taba (Gilbertese).

Synonymy:

Mugil vaigiensis Quoy and Gaimard: Voyage *Uranie*, Zool., p. 337, 1825 (original description). Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 124, 1928 (synonymy).

Distribution:

Not known from the Hawaiian or Leeward Islands. In the Line Islands from Christmas (Fowler, 1938, p. 276) and Palmyra (Fowler, 1938, p. 276; 1 specimen, POFI cat. No. 530, 68 mm. t. l.). In the Phoenix Islands from Canton (Schultz, 1943, p. 81; 10 specimens, POFI cat. Nos. 527, 528, 529, 534, and 547, 73–222 mm. t. l.; 7 specimens, U. H. cat. No. 1040, 120–224 mm. s. l.) and Hull (Schultz, 1943, p. 81).

Importance:

A fair bait species for pole-and-line fishing. It appears to be the most common species of mullet in the Line and Phoenix Islands.

BLUE-TAIL MULLET, *Mugil longimanus* Günther. Fig. 14.

Figure 14.—*Mugil longimanus*, blue-tail mullet; te bawa (Gilbertese).

Local name: Te bawa (Gilbertese).

Synonymy:

Mugil longimanus Günther: Cat. Fishes Brit. Mus., vol. 4, p. 248, 1861 (original description). Fowler: B. P. Bishop Mus., Bull. 38, p. 9, 1927 (distribution).

Distribution:

Not known from the Hawaiian and Leeward Islands. In the Line Islands from Palmyra (Fowler, 1928, p. 123, 1938, p. 276) and Christmas (Fowler, 1928, p. 123, 1938, p. 276). In the Phoenix Islands from Canton (21 specimens, POFI, cat. Nos. 516, 524, 540, 542, 545, and 546, 32–183 mm. t. l.).

Importance:

A fair live-bait fish for pole-and-line fishing. Sometimes occurs in considerable quantities in the Line Islands at Palmyra and Christmas and in the Phoenix Islands at Canton.

STRIPED MULLET, *Mugil cephalus* Linnaeus. Fig. 15.

Figure 15.—*Mugil cephalus*, striped mullet; amaama (Hawaiian); te aua, te paueriki (Gilbertese).

Local names: Amaama (Hawaiian); te aua, te paueriki (Gilbertese).

Synonymy:

Mugil cephalus Linnaeus: Systema Nat., 10th ed., p. 316, 1758 (original description). Jordan and Evermann: U. S. Fish Comm., Bull., vol. 23, pt. 1, p. 139, 1905 (description). Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 125, 1928 (distribution).

Distribution:

Reported from the Hawaiian Islands (Fowler, 1928, p. 125, 1938, p. 276; Jordan and Evermann, 1905, p. 139). In the Leeward Islands from Laysan, Lisianski, French Frigate Shoal (Fowler and Ball, 1925, p. 10; Fowler 1927, p. 9, 1928, p. 125), Pearl and Hermes Reef (Galtsoff, 1933, p. 20; 4 specimens, POFI cat. No. 424, 25–32 mm. t. l.), and Midway Islands (1 specimen, POFI cat. No. 513, 37 mm. t. l.).

Importance:

A fair live-bait fish for pole-and-line fishing. It seems to occur most abundantly at Midway Islands.

THICK-LIP MULLET, *Crenimugil crenilabis* (Forskål). Fig. 16.

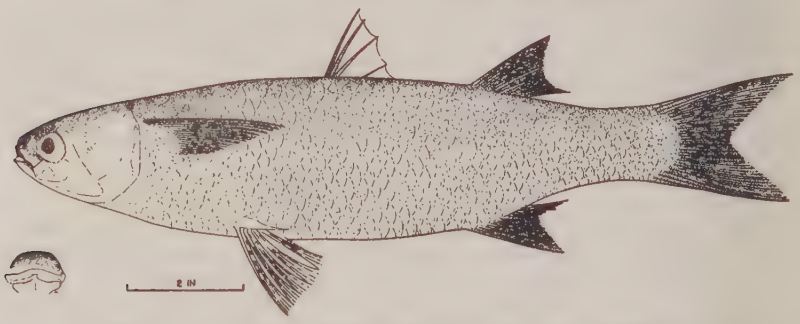

Figure 16.—*Crenimugil crenilabis*, thick-lip mullet; te aua (Gilbertese).

Local name: Te aua (Gilbertese).

Synonymy:

Mugil crenilabis Forskål: Descriptiones Animalium, pp. 14 and 73, 1775 (original description).

Crenimugil crenilabis Schultz: U. S. Natl. Mus., Proc., vol. 96, p. 387, 1946 (synonymy).

Distribution:

Not known from the Hawaiian or Leeward Islands. In the Line Islands from Palmyra, Fanning (Fowler, 1938, p. 276), and Christmas (Fowler, 1928, p. 126, 1938, p. 276; 2 specimens, POFI cat. No. 722, 180–195 t. l.). In the Phoenix Islands from Canton (Schultz, 1943, p. 81; 3 specimens, POFI cat. Nos. 1446, 1447, and 1448, 170–200 mm. t. l.) and Hull (Schultz, 1943, p. 81).

Importance:

A fair bait fish for pole-and-line fishing. Small fish of this species are not so common in the Line and Phoenix Islands as are other members of the family.

Threadfins—Family POLYNEMIDAE

These fishes have pectoral fins which consist of two parts; the lower, anterior part is composed of separately jointed filaments which in some specimens are longer than the body. The body is oblong and covered with rather small, ctenoid scales, which also are found on the head and usually on the dorsal and anal fins. The large mouth is nearly horizontal with bands of small teeth on the jaws, palatines, pterygoids,

and sometimes on the vomer. The snout is conical, projecting beyond the upper jaw or mandible. The lateral line is complete, extending on the deeply forked caudal fin. There are two well-separated dorsal fins, the first with 7 to 8 flexible spines and the second dorsal with soft rays only. The eye is anteriorly placed and covered by an adipose lid. In life, most threadfins are bluish gray above, pale below, and sometimes marked with faint black stripes along the scale rows.

There are many species distributed in tropical seas; however, only a single species comes within the scope of the present work. The threadfins are carnivorous fishes that inhabit sandy shores in shallow water; some enter estuaries or rivers. The young often travel in schools along the shores and reefs. Most of the species in the family are rather small, but one species from Indian waters is reported to reach a length of nearly 6 feet. These fishes are important as food in many places in the tropics.

THREADFIN, *Polydactylus sexfilis* (Valenciennes). Fig. 17.

Figure 17.—*Polydactylus sexfilis*, threadfin; moi (Hawaiian).

Local name: Moi (Hawaiian).

Synonymy:

Polynemus sexfilis Valenciennes: Hist. Nat., Poiss., vol. 7, p. 515, 1831 (original description).

Polydactylus sexfilis Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 131, 1928 (synonymy, distribution).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 144; Fowler, 1928, p. 131, 1938, p. 219). In the Leeward Islands from Laysan, Lisianski, French Frigate Shoal (Fowler and Ball, 1925, p. 11), and Midway Islands (1 specimen, U. H. cat. No. 1046, 195 mm. s. l.). From Johnston Island (Jordan and Evermann, 1905, p. 145). Not known from the Line or Phoenix Islands.

Importance:

Where available, small threadfins provide suitable bait for pole-and-line fishing. They often are captured in the nets during seining operations for other bait species.

Jacks, pompanos, and cavallas—Family CARANGIDAE

In the carangids, the body is elongate to ovate, moderately to very strongly compressed, and with a very slender caudal peduncle. The anal fin is long and preceded by 2 strong, separate spines. The ventral fins are thoracic in position, with 1 spine and 5 rays. Scales are small, cycloid, and thin, sometimes embedded, occasionally absent. There are two dorsal fins, the first spinous dorsal being rather flexible and usually folding into a groove. The caudal fin is widely forked. In life, the fishes in the family generally are metallic and silvery or golden in coloration.

The jacks are swift-swimming, carnivorous fishes that occur most abundantly in warm seas. Many of the species are pelagic, but some travel in schools and may approach the shores and shallow-water reefs where they often are seen swimming with the dorsal fins projecting above the surface. Most of the group are of economic importance as food, and certain forms serve as forage for many of the commercially important fishes.

KEY TO THE SPECIES

1. Lateral line not armed with scutes or bony plates; premaxillaries not protractile----------
LEATHERJACKET (*Scomberoides sancti-petri*)
Lateral line armed with scutes or bony plates; premaxillaries protractile---------- 2
2. A single, free finlet behind both second dorsal and anal fins; about 25 scutes in lateral series----------
MACKEREL SCAD (*Decapterus pinnulatus*)
No free finlets behind second dorsal or anal fins; 35–36 scutes in lateral series----------
BIG-EYED SCAD (*Trachurops crumenophthalmus*)

LEATHERJACKET, *Scomberoides sancti-petri* (Cuvier). Fig. 18.

Local names: Lai (Hawaiian); te nari (Gilbertese).

Synonymy:

Chorinemus sancti-petri Cuvier: Hist. Nat., Poiss., vol. 8, p. 379, 1831 (original description).

Scomberoides sancti-petri Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 141, 1928 (synonymy, distribution).

Figure 18.—*Scomberoides sancti-petri*, leatherjacket; lai (Hawaiian); te nari (Gilbertese).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 181; Fowler, 1927, p. 11). Not known from the Leeward Islands, but reported from Johnston Island (Fowler and Ball, 1925, p. 12). In the Line Islands from Christmas (Fowler, 1928, p. 141, 1938, p. 196), Fanning (Fowler, 1938, p. 209), and Palmyra (1 specimen, POFI cat. No. 167, 30 mm. t. l.). In the Phoenix Islands from Canton (Schultz, 1943, p. 87; 3 specimens, POFI cat. Nos. 166, 172, and 183, 36–81 mm. t. l.).

Importance:

The leatherjacket is not an important bait fish, however, small specimens frequently are caught in the nets during bait-fishing operations for other species. The dried skin of the adult is much in demand by Hawaiian skipjack fishermen for making jigs or strikers; a small piece of skin is wrapped around the base of the feathers to prevent fraying.

MACKEREL SCAD, *Decapterus pinnulatus* (Eydoux and Souleyet). Fig. 19.

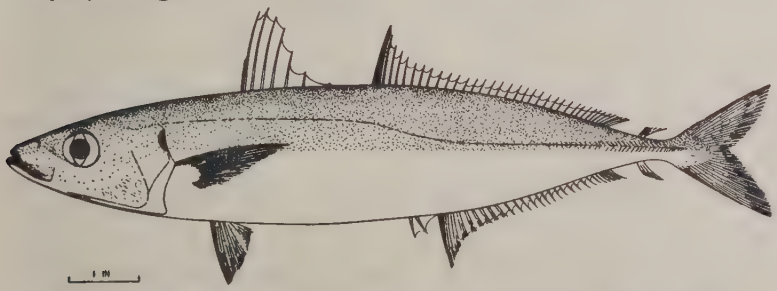

Figure 19.—*Decapterus pinnulatus*, mackerel scad; opelu (Hawaiian); te ika rikiriki (Gilbertese).

Local names: Opelu (Hawaiian); te ika rikiriki (Gilbertese).

Synonymy:

Caranx pinnulatus Eydoux and Souleyet: Voyage *Bonite*, Zool., vol. 1, p. 165, 1841 (original description).

Decapterus sanctae-helenae Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 143, 1928 (synonymy, distribution).

Decapterus pinnulatus Fowler: B. P. Bishop Mus., Mem., vol. 12, No. 2, p. 75, 1949 (synonymy).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 186; Fowler, 1928, p. 143). In the Leeward Islands from Lisianski (Fowler and Ball, 1925, p. 12). In the Line Islands from Fanning (1 specimen, POFI cat. No. 1465, 230 mm. t. l.). In the Phoenix Islands from Hull (1 specimen, POFI cat. No. 736, 175 mm. t. l.) and from Birnie (3 specimens, POFI cat. Nos. 1463 and 1464, 250–280 mm. t. l.).

Importance:

In the Hawaiian Islands, the mackerel scad is the most preferred of the fish species used for bait by the longline fishermen.

BIG-EYED SCAD, *Trachurops crumenophthalmus* (Bloch). Fig. 20.

Figure 20.—*Trachurops crumenophthalmus*, the big-eyed scad; akule (Hawaiian); te bari? (Gilbertese).

Local names: Akule (Hawaiian); te bari? (Gilbertese).

Synonymy:

Scomber crumenophthalmus Bloch: Nat. ausländischen Fische, vol. 7, pt. 10. p. 77, 1793 (original description).

Selar crumenophthalmus Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 144, 1928 (synonymy, distribution).

Trachurops crumenophthalmus Schultz: U. S. Natl. Mus., Bull. 180, p. 86, 1943 (synonymy).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 187; Fowler, 1928, p. 144). No records from the Leeward Islands or Johnston Island. In the Line Islands from Christmas (Fowler, 1928, p. 144, 1938, p. 196). No records from the Phoenix Islands.

Importance:

The big-eyed scad is used to a certain extent for longline bait in the Hawaiian Islands, but it is most important as a food fish.

Mountain basses—Family KUHLIIDAE

In this family, the body is oblong and strongly compressed. The lateral line is complete. The mouth is large and protractile. The single dorsal fin is deeply notched, consisting of a well-developed spinous part with 10 strong spines and a soft part with 9 to 13 rays. The gill membranes are separate; the opercle has 2 small, flat spines. The anal fin has 3 spines and 10 to 12 rays. Both the dorsal and anal fins fit into a scaly sheath. As adults, these fishes are bright silvery on the sides and belly and bluish gray above, often with dark marbling on the head and shoulder. The young show much variation in coloration and in markings.

The family is widespread in distribution, inhabiting shallow, tropical waters of the Indian and Pacific Oceans. Some members of the group spend their entire lives in marine waters, others enter brackish water, and some frequent estuaries and enter fresh water. They are believed to spawn along the shores, and after hatching, the young are reported to seek shelter in coral holes and pools where they develop until they reach nearly adult size (Pietschmann 1938). A single species, *Kuhlia sandvicensis*, comes within the scope of this report, and is the only common member of the family occurring in the central Pacific region. Other species, *K. taeniura* (Cuvier) and *K. petiti* Schultz, have been reported from the region; however, these species do not appear commonly at any of the island areas covered by the present report. For field identification, the caudal fin of *K. sandvicensis* is without black bars or spots, but with the posterior margin blackish. *K. taeniura* is reported to bear characteristically 5 diagonal black bars on the caudal fin; a wide black band occupies the outer third of each caudal lobe and the tips of the rays are white (Smith and Swain 1882, Schultz 1943), *K. petiti* described and reported by Schultz (1943) from the Phoenix Islands is reported to be distinguished by the black marginal markings and by the large, black spot on the central portion of both the upper and lower lobe of the caudal fin. Neither of these species have been caught in the bait nets, nor have

they been found in the reef and lagoon collections made in the region by POFI biologists. The mountain bass is an excellent food fish, and in Hawaii it is sought as a game fish.

MOUNTAIN BASS, *Kuhlia sandvicensis* (Steindachner). Fig. 21.

Figure 21.—*Kuhlia sandvicensis*, mountain bass; aholehole (Hawaiian); te tintin (Gilbertese).

Local names: Aholehole (Hawaiian); te tintin (Gilbertese).

Synonymy:

Moronopsis argenteus var. *sandvicensis* Steindachner: Akad. Wiss. Wien Sitz., vol. 74, pt. 1, p. 157, 1877 (original description).

Kuhlia sandvicensis Fowler: B. P. Bishop Mus., Mem., vol. 10, p. 170, 1928 (synonymy). Schultz: U. S. Natl. Mus., Bull. 180, p. 101, 1943 (synonymy, list of specimens).

Dules sandvicensis Fowler: B. P. Bishop Mus., Mem., vol. 12, No. 2, p. 83, 1949 (synonymy, list of specimens).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 208; Fowler, 1928, p. 170). In the Leeward Islands from Necker, Nihoa, French Frigate Shoal, Lisianski, Pearl and Hermes Reef (Fowler and Ball, 1925, p. 13), Laysan (Jordan and Evermann, 1905, p. 208; Fowler and Ball, 1925, p. 13), and Midway Islands (64 specimens, POFI cat. Nos. 451, 452, and 455, 32–157 mm. t.l.). From Johnston Island (Fowler and Ball, 1925, p. 13). In the Line Islands from Palmyra (Fowler, 1928, p. 170), Fanning and Jarvis (Fowler, 1927, p. 13). In the Phoenix Islands from Canton (Schultz, 1943, p. 101), Hull and Enderbury (Schultz, 1943, p. 101).

Importance:

The mountain bass is one of the more-common, small fish species found in the Leeward Islands, and it appears to be most

abundant at Midway Islands. As a live-bait fish it is excellent and will withstand long-distance transportation in the bait tanks if properly handled.

Goatfishes or surmullets—Family MULLIDAE

Members of this family have an elongated, compressed body. The forehead is rounded, with the eyes placed high. The mouth is low and more or less terminal. The maxillaries are thin and very broad. The premaxillaries are protractile. The family is distinguished from others treated in this report by having two long, unbranched barbels attached just behind the anterior rim of the lower jaw. The lateral line is complete, with the pores branched. The teeth are small and variously placed. Scales are large, usually ctenoid, and extend forward onto the head. There are two well-separated dorsal fins, the first with 6 to 8 spines. The anal fin is short (similar to the second dorsal), with 1 or 2 spines. The surmullets all are brilliantly colored with red or yellow.

The surmullets are widely distributed in all tropical seas, and some members of the family occur in temperate waters. In the central Pacific, the family is represented in the Leeward, Line, and Phoenix Islands, where they are found along the shorelines, both inside and outside the various lagoons, atolls, and reef areas.

Members of the family are mostly small fishes found in the shallow waters inside the reefs of tropical seas; some enter estuaries and rivers. They often occur in large schools close to shore where they may be seen swimming close to the bottom stirring up mud and sand with the barbels. Their food consists of organic materials stirred up by the barbels as they forage over the bottom. In addition to their importance as an excellent food fish, they serve as food for many predaceous fishes.

KEY TO THE SPECIES

Three genera and 17 species of the family Mullidae have been reported from the central Pacific. The present work considers two members of the group, *Mulloidichthys auriflamma* and *M. samoensis*, for they have been the only species present in quantity in the bait catches made in the region and therefore are assumed to be the most common.

Separation of the various genera and species is difficult and a detailed taxonomic treatment of the group is beyond the scope of this report. In general, the species of the genus *Pseudupeneus* [=*Parupeneus*] are deep-bodied fish without yellow lateral bands on the

sides of the body. They occur among coral reefs but have not been taken in any of our bait collections. Members of the genus *Upeneus* are distinguished from members of the genus *Mulloidichthys* by the presence of teeth on the vomer and palatines; the former genus occurred infrequently in the bait collections.

A single yellow band on side of body, forehead rounded, eye large, 3.5 to 3.7 in head length; no black spot on body beneath tip of pectoral fin; no black spot on inside of opercle forward of pseudobranch; belly reddish with orange ventral and anal fins ---------- GOLDEN GOATFISH (*Mulloidichthys auriflamma*)

Several small yellow stripes on sides of body, one above and three below the median band; head long, eye small, 3.9 to 4.1 in head length; faint black spot on body beneath tip of pectoral fin; black spot on inside of opercle just forward of pseudobranch; belly white or pinkish with white ventral and anal fins ---------- SAMOAN GOATFISH (*Mulloidichthys samoensis*)

GOLDEN GOATFISH, *Mulloidichthys auriflamma* (Forskål). Fig. 22.

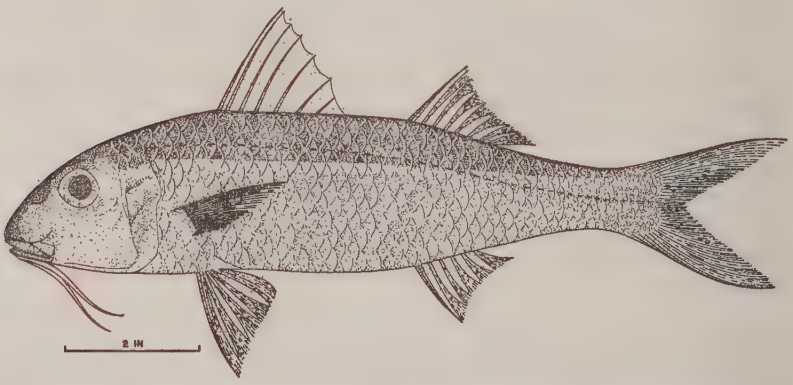

Figure 22.—*Mulloidichthys auriflamma*, golden goatfish; weke (Hawaiian); te mawa (Gilbertese).

Local names: Weke (Hawaiian); te mawa (Gilbertese).

Synonymy:

Mullus auriflamma Forskål: Descriptiones Animalium, pp. 10 and 30, 1775 (original description).

Mulloides auriflamma Jordan and Evermann: U. S. Fish Comm., Bull., vol. 23, pt. 1, p. 251, 1905 (synonymy, description, distribution).

Mulloidichthys auriflamma Schultz: U. S. Natl. Mus., Bull. 180, p. 129, 1943 (synonymy, list of specimens). Fowler: B. P. Bishop Mus., Mem., vol. 12, No. 2, p. 94, 1949 (synonymy).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 250; Fowler, 1928, p. 233, 1938, p. 223). In the Leeward Islands from French Frigate Shoal (Fowler and Ball, 1925, p. 15) and Midway Islands (4 specimens, POFI cat. No. 1453, 109–123 mm. t.l.). From Johnston Island (Fowler and Ball, 1925, p. 15). In the Line Islands from Fanning (Fowler, 1938, p. 211) and Christmas (4 specimens, POFI cat. No. 553, 45–86 mm. t. l.). In the Phoenix Islands from Canton (Schultz, 1943, p. 129; 3 specimens, POFI cat. No. 551, 80–86 mm. t.l.) and Hull (Schultz, 1943, p. 129).

Importance:

This species of goatfish is suitable for use as live bait. In the islands where it occurs, it is one of the more common fishes, and often is encountered in fairly large schools close to shore.

SAMOAN GOATFISH, *Mulloidichthys samoensis* (Günther). Fig. 23.

Figure 23.—*Mulloidichthys samoensis*, Samoan goatfish; weke (Hawaiian); te mawa (Gilbertese).

Local names: Weke (Hawaiian); te mawa (Gilbertese).

Synonymy:

Mulloides samoensis Günther: Mus. Godeffroy, Jour., vols. 2–3, pts. 5–6, p. 57, 1874 (original description).

Mulloidichthys samoensis Fowler: B. P. Bishop Mus., Mem., vol. 12, No. 2, p. 94, 1949 (synonymy, list of specimens).

Distribution:

Reported from the Hawaiian Islands (Jordan and Evermann, 1905, p. 253; Fowler 1928, p. 234, 1938, p. 223). In the Leeward Islands from Laysan (Fowler and Ball, 1925, p. 15; Fowler, 1927, p. 16) and Lisianski (Fowler and Ball, 1925, p. 15). From Johnston Island (Fowler, 1928, p. 235). In the Line Islands from Christmas (Fowler, 1927, p. 16, 1938, p. 201). In the Phoenix Islands from Canton and Hull (Schultz, 1943, p. 129).

Importance:

This species is suitable for use as live tuna bait, and has appeared in the bait catches made at various islands in the region.

Evaluation of Tuna-Bait Resources of the Central Pacific

One of the objectives of the Pacific Oceanic Fishery Investigations is to determine the availability of the commercially important tunas in the waters of the central Pacific Ocean to the standard fishing methods and gear employed in the tuna fishery of the west coasts of the American continents. In the American tuna fishery, clipper-type fishing vessels, in which live bait is carried in large quantities to the fishing grounds and used to attract and hold schools of tuna while they are caught with hook and line, have become the principal means for exploiting the yellowfin tuna and skipjack stocks in the eastern Pacific Ocean.

Similar operations were planned for the initial exploration of the tuna resources of the equatorial waters of the central Pacific. For such operations to be feasible, the presence of bait stocks in sufficient quantities to permit the capture of live-bait supplies in the region would be necessary. From the results of bait-fishing operations by various Hawaiian fishing vessels and the *Oregon* of the Pacific Exploration Company, it appeared likely that quantities of live bait sufficient for tuna-clipper operations were obtainable, at least at certain islands and reefs in the region (Smith and Schaefer 1949). In the American tuna fishery, a normal load of live bait for a successful fishing voyage of a clipper vessel consists of between 2,000 and 3,000 scoops, each containing about 10 pounds of fish.

The present report summarizes the information on the tuna-bait resources of this region accumulated over the 2-year period, June 1949 through June 1951. Most of the data were collected by biologists of the Pacific Oceanic Fishery Investigations during hydrographic and exploratory-fishing cruises of the research vessels, *Hugh M. Smith* and *Henry O'Malley*, both clipper-type vessels. During the period February 1950 through June 1951 seven cruises were made by these vessels to various island areas in the region to search for live bait for use in pole-and-line tuna fishing. Field observations on the occurrence, habits, habitat preferences, and methods of capture of bait species were made at every opportunity at each of the islands considered in this report. Specimens for reference purposes were obtained from the catches made during seining operations for live bait for use on the exploratory tuna-fishing voyages, from poison stations conducted in lagoons and reef areas, and from

night-light fishing stations at which a submarine light and a dip net were used to attract and capture the fish.

A description of each potentially important baiting area is given, and the results of the observations and bait-fishing activities conducted by various members of the Pacific Oceanic Fishery Investigations staff are briefly summarized. As the evaluation may be based on a few brief visits to some areas, any periodic fluctuations in the bait stocks may have distorted the conclusions. Additional observations at regular intervals will be necessary to complete an appraisal of the resources of each baiting area. All islands and island groups referred to in this report are shown in figure 1.

Hawaiian Islands

The eight major islands comprising the Hawaiian group are Hawaii, Maui, Molokai, Lanai, Kahoolawe, Oahu, Kauai, and Niihau. They lie at the southeastern end of an archipelago which extends from the island of Hawaii on the southeast to Niihau Island on the northwest. The islands are of volcanic origin and reach a maximum elevation of nearly 14,000 feet above sea level. In many places coral reefs fringe a sandy beach, or jagged volcanic rocks lie strewn along the shores, but in others steep, rocky cliffs rise abruptly out of the deep waters. Numerous bays and coves indent the coastlines, and it is the larger of these and the fresh-water streams that provide suitable habitats for numerous species of shore fishes, some of which are utilized for tuna bait.

The Hawaiian anchovy (*Stolephorus purpureus*) is by far the most important of the small fishes used in the commercial live-bait fishery for skipjack (*Katsuwonus pelamis*). The anchovy, or nehu, as it is known locally, constitutes about 95 percent of the entire bait-fish catch. In terms of tuna production, it was mainly responsible for about 8½ million pounds of skipjack in 1948 and nearly 10 million pounds in 1949. In addition to this species, the Hawaiian silversides, or iao, (*Pranesus insularum*), sailfin molly (*Mollienesia latipinna*), and small round herring, or piha, (*Spratelloides delicatulus*), when obtainable, also are utilized for skipjack bait. Of these latter, the silversides is the most important.

The island of Oahu furnishes the chief baiting grounds for these species. In 1948 Kaneohe Bay, Pearl Harbor, Ala Wai Canal, and Honolulu Harbor contributed roughly 60 percent of the entire anchovy catch. The island of Maui ranks second as a source of skipjack bait, contributing about 27 percent of the anchovy catch in 1948. The main baiting center on Maui is Maalaea Bay. The other islands also provide fairly extensive baiting grounds, but they are of limited

importance in terms of bait production. Among these, Hilo Bay on the island of Hawaii and Hanalei and Nawiliwili Bays on Kauai are most noteworthy.

As noted above, the availability of the Hawaiian anchovy is one of the main factors governing the size of the commercial skipjack catch in local waters. In recent years, however, certain baiting areas, including Kaneohe and Hilo Bays, have shown evidence of an apparent decline in the availability of this species. An intensive research program was initiated in 1948 under the auspices of the University of Hawaii to study the biology and population dynamics of the anchovy in Kaneohe Bay, knowledge of which eventually may result in an optimum utilization of the available stocks.

In conclusion, the presently available bait stocks in the Hawaiian Islands proper cannot support a substantial increase in fishing pressure. An appreciable expansion of the local tuna fisheries dependent upon live bait would require that bait be obtained elsewhere.

Leeward Islands

The Leeward Island chain extends northwestward of the Hawaiian Islands proper to Midway and Kure (Ocean) Islands. Most of the islands in the chain are of coral and of rather small size. In the following discussion, only French Frigate Shoal, Laysan Island, Lisianski Island, Pearl and Hermes Reef, and the Midway Islands will be considered in detail.

French Frigate Shoal

This crescent-shaped reef area is located near the easterly end of the Leeward chain. It is approximately 17 miles long in a northwesterly-southwesterly direction and about 12 miles wide at the southern end. The reef area surrounds about 11 small, bare islets which rise a maximum of 10 or 12 feet above the shallow waters, although most of them are much lower. The islets have sand beaches interrupted by occasional patches of coral, and it is along the sand beaches where schools of small fish, suitable for live tuna bait, most commonly occur.

On the first visit to French Frigate Shoal by the *Oregon* in January 1948, Smith and Schaefer (1949) reported considerable quantities of bait fish present in the area. During 10 days of scouting and fishing, approximately 450 scoops of Hawaiian silversides, or iao, were caught and placed in the *Oregon's* bait tanks. In August of the same year the *Oregon* returned to the area. Eckles (1949) reported that about 900 scoops of the same species were caught in the shallow waters surrounding the sandy islets on this trip.

During the first visit to the area by the senior author in May 1949, observations on the occurrence of potential bait species were made in the waters surrounding several of the sand islets. No quantities of small fishes were observed along the sandy shores, although small scattered schools of various species of fish (mostly mountain bass, Kuhliidae) were sighted among the coral patches near shore.

In 1950, the *Hugh M. Smith* visited the Shoal during the periods January 19 to 25 and June 19 to 21, and again during the period May 8 to 11, 1951, in search of bait for pole-and-line tuna fishing. The waters surrounding each of the islets in the area were scouted thoroughly during each visit, but only small quantities of various bait species were observed. A total of only 42 buckets of bait, consisting of Hawaiian silversides, false mullet (*Neomyxus chaptalii*), and mountain bass (*Kuhlia sandvicensis*), were caught during these visits. A "bucket" of bait fish, as the term is used in Hawaii, is equal to about 1¼ scoops, the latter being the common measure employed by American tuna fishermen. Roughly, a bucket contains between 8 and 13 pounds of fish. The *Henry O'Malley* visited the same area during three different periods in 1950; January 7 to February 6, May 19 to 25, and July 4 and 5. A total of only 31 buckets of bait was caught on these trips, consisting of Hawaiian silversides, mountain bass, and small round herring. Very few schools of small bait fish were observed in the shallow waters surrounding the islets on these occasions. Hawaiian silversides appeared most commonly in the bait catches of both vessels.

This scouting, together with the results of the bait-fishing operations, indicates that the stocks of small fishes at French Frigate Shoal apparently do not represent a dependable source of live bait to support profitable tuna-clipper operations.

Laysan Island

This oval, coral sand island lies northwestward of French Frigate Shoal, between Gardner Pinnacles and Lisianski Island. It is approximately 2 miles long in a north-south direction and about 1 mile wide. At its center lies a salt lake less than 15 feet in depth which is without connection with the sea. The island is surrounded by coral reefs, with the coral beaches occasionally interrupted by small stretches of sand. The coral sand and reef areas provide a very limited habitat of suitable type for small shore fishes.

On visits to the island by the *Hugh M. Smith* on June 23, 1950, and again on May 12, 1951, the island waters were scouted for bait. On these occasions, only two or three very small schools of mountain bass were sighted, and no sets were made with the bait nets.

From these observations it appears that Laysan Island probably does not support small bait species in sufficient quantities to warrant consideration as a source of live tuna bait.

Lisianski Island

Lisianski Island lies approximately 115 miles northwest of Laysan Island. It is slightly over a mile long in a north-south direction and about three-quarters of a mile wide. The island is situated on the northern extremity of a large reef platform which is several miles in length. The white sand beaches surrounding most of the island are interrupted at places by extensive patches of rough coral which reach to the shoreline.

The *Hugh M. Smith* visited the island on June 24, 1950, and again on May 13, 1951. On the first trip, only small scattered schools of Hawaiian silversides and mountain bass were observed, and nowhere were these species encountered in large enough quantities to make baiting operations worthwhile. On the second visit to the island, 10 buckets of Hawaiian silversides and 73 buckets of mountain bass were captured along the sand beaches of the north and northeast sides in seven sets of a 40-fathom beach seine. Several schools of small threadfin (*Polydactylus sexfilis*) were observed over the coral patches, but the numerous coral heads precluded seining attempts; however, a few individuals of this species were taken in the nets during the sets made on the mountain bass.

Because of the lack of suitable anchorage for clipper-size vessels close to the baiting grounds, it was necessary to transport the captured bait a considerable distance among dangerous coral heads and over the reef through fairly heavy surf. The mountain bass especially sustained excessive mortality due to injuries received during the transit from the site of capture to the vessel anchorage.

On the basis of these findings, it appears likely that Lisianski Island is not a suitable baiting area for tuna-clipper vessels because of the limited bait stocks observed in the area and the difficulties encountered in transporting captured bait from the bait grounds to the tanks aboard the fishing vessel.

Pearl and Hermes Reef

This coral atoll lies about 150 miles northwest of Lisianski Island. It is slightly over 40 miles in circumference, 17 miles long in an easterly direction, and 9 miles wide. The eastern side of the reef is continuous, but there is a relatively shallow entrance to the lagoon located on the northwest side. There are 12 small, scattered sand bars and islets which lie on the reef along the eastern, southeastern, and southern sides.

The atoll was visited on two occasions by the *Hugh M. Smith* in search of live-bait supplies. On the first voyage to the area, during the period June 25 to 27, 1950, observations were made on the occurrence of suitable bait species at each of the islets and in the waters of the large lagoon. Small schools of Hawaiian silversides and small round herring were sighted along several of the sand bars, but they were not present in sufficient quantities to make baiting attempts practicable. On the second visit, May 14, 1951, the shallow waters surrounding each islet and bar were scouted for bait; however, three small schools of mountain bass and several schools of small round herring were the only signs of bait observed. These were not considered worth while for seining operations.

It appears that Pearl and Hermes Reef potentially may contain fairly large bait stocks, by virtue of the extensive lagoon area, but it is also evident that the availability of these stocks cannot be considered dependable for tuna-clipper operations.

Midway Islands

Two low islands lie on the southern rim of this nearly circular, coral atoll. The atoll is approximately 5 miles in diameter and encloses a central lagoon. Eastern Island, which lies on the southeast side of the reef, is about 1¼ miles long and ¾ mile wide. It has extensive white coral sand beaches along the south and northwest sides. The eastern side is broken by heavy coral rocks. Sand Island is 1¾ miles long, 1 mile wide, and nearly completely surrounded by extensive white coral sand beaches. There are adequate mooring facilities for clipper-size vessels.

At the present time, Midway is a restricted area, and all vessels approaching within 5 miles of the islands must obtain permission from proper naval authority.

During 1950 the *Hugh M. Smith* visited the islands in search of bait during the period June 28 to 29, and again in 1951 during the period May 16 through 19. The *Henry O'Malley* visited the area during the period July 9 to 13, 1950.

On the first trip of the *Hugh M. Smith*, bait fishing was not attempted, although schools of Hawaiian silversides, small round herring, mountain bass, and goatfish were in evidence around both Sand and Eastern Islands. During baiting activities on the second trip, a total of 570 buckets of bait, consisting of 20 buckets of Hawaiian silversides, 151 buckets of golden goatfish (*Mulloidichthys auriflamma*), and 399 buckets of mountain bass, was captured during 3½ days' seining along the beaches of Sand and Eastern Islands. In addition, large quantities of small round herring were observed along the eastern shore of Sand Island, but no attempts were made to

seine this species. All available tanks and wells aboard the vessel were loaded, and no further baiting attempts were made, although observations indicated that large quantities of the species captured still were readily available, especially around Sand Island.

On the single visit to the area by the *Henry O'Malley*, a total of 446 buckets of bait was captured, consisting of 19 buckets of Hawaiian silversides, 226 buckets of small round herring, 26 buckets of goatfish, 164 buckets of mountain bass, and 11 buckets of striped mullet (*Mugil cephalus*). These catches were made along the sand beaches of both Sand and Eastern Islands.

The results of the baiting activities of both the *Hugh M. Smith* and the *Henry O'Malley* indicate that Midway Islands offer the most promising source of bait in the Leeward chain. Because of the limited habitats available, it appears that this area could not support the extensive bait stocks necessary for the continuous and profitable operation of clipper-type vessels. Before final evaluation of the area could be made, it would be necessary to conduct frequent and extended observations and baiting operations to determine the magnitude of these bait stocks and their variations in abundance through the year. It should be noted that Hawaiian silversides have been reported by United States Navy personnel stationed on Sand Island as occurring there in great numbers during late summer. Samples of this species obtained during this period of apparent heavy concentration were found to consist exclusively of adult, spawning fish. Furthermore, samples of this species taken from the bait catches made during each baiting operation in all of the Leeward Islands consisted almost exclusively of adult, near-spawning fish. These observations suggest that this fish may congregate along the beaches in the greatest numbers at the time of spawning, as has been shown for other members of the family, *Leuresthes tenuis* and *Atherinopsis californiensis*, found along the coast of California (Clark 1925 and 1929).

Johnston Island

Johnston Island lies about 717 miles west-southwest of Honolulu. It is a small coral island, about ½ mile in length and several hundred yards in width. Lying approximately 1 mile to the northeast of the main island is a small coral island known as Sand Island. These islands lie on a shallow, semicircular reef that measures nearly 7 miles across. The area is a "Defensive Sea Area and Airspace Reservation," and vessels are not allowed within 3 miles of it except by authorization of the Secretary of the Navy.

The *Hugh M. Smith* visited Johnston Island on May 25, 1951, during which time the shallow waters surrounding both coral sand

islands were scouted for tuna bait. Several small schools of mullet and goatfish were sighted along the south shores of both Johnston and Sand Islands; however, these were not present in sufficient quantities to make seining operations worth while.

Because of dredging done during the building of the airstrip, the beaches of these islands are covered with dead coral, and thus do not provide suitable habitats for many of the shore-dwelling fish species. Furthermore, there exist only very limited stretches of coral sand beaches which would be suitable for operation of a beach seine. Thus, it does not appear that Johnston Island would be a profitable source of bait.

Line Islands

The scattered islands which lie near the meridian of 160° W. longitude and extend from about 6° N. to about 14° S. latitude are commonly referred to as the Line Islands. In this report, only three islands of this group—Palmyra, Fanning, and Christmas—will be considered.

Palmyra Island

This atoll, consisting of a series of small islets enclosing three lagoons, lies about 960 miles south and west of Honolulu. It has a land area of approximately 250 acres and is about 5 miles long in an east-west direction and 1½ miles wide. The lagoons are separated from each other, West Lagoon being the largest. Depths inside the lagoons are reported to reach a maximum of 160 feet. A coral platform forms a barrier on the seaward side of the islets. Suitable anchorage and mooring for clipper-size vessels are available inside West Lagoon.

At present, the island has been designated a "Defensive Sea Area and Airspace Reservation," and authorization must be obtained for vessels approaching within 3 miles.

A survey of the bait resources of the area was first made by the senior author in June 1949 and the findings published (June 1950). Several species of mullet (*Crenimugil crenilabis*, *Mugil vaigiensis*, and *M. longimanus*), of sizes suitable for use as live bait, were reported as occurring in great numbers in East Lagoon. The schools ranged in size "from a few scoops to a hundred or more." Large quantities of milkfish also were present in the three lagoons; goatfish were fairly abundant in West Lagoon. The *Hugh M. Smith* visited the island on two occasions, November 4, 1950, and June 2, 1951, in search of bait. On the first visit, 38 buckets of black-fin mullet and blue-tail mullet (*Mugil vaigiensis* and *M. longimanus*) were captured in West Lagoon, off Paradise and Home Islands. Dur-

ing the second baiting attempt, 115 buckets of mullet of the same species were captured in five sets of a 40-fathom beach seine in the shallow waters off Paradise Island. Although additional mullet could have been obtained fairly easily on both occasions, it was evident that these species did not occur in the same relative abundance noted on the initial survey.

It is concluded that Palmyra Island offers stocks of mullet and other small shore fishes in the lagoons for use as supplemental bait to more suitable live-bait species.

Fanning Island

Fanning is an atoll lying about 152 miles northwest of Christmas Island and 288 miles north of the Equator. It is roughly oval in shape and measures about 9½ miles long in a northwest-southeast direction by about 6 miles wide. The island encloses a shallow lagoon, with an entrance at English Harbor on the southwest side. The island is surrounded by a steep, narrow, fringing reef. Suitable anchorage may be found on the northwest side.

Fanning Island is administered as part of the British Crown Colony of the Gilbert and Ellice Islands and a British district officer is stationed on the island.

The waters inside the lagoon were scouted for bait on two occasions during visits to the island by the *Hugh M. Smith*, on November 15, 1950, and June 6, 1951. On both surveys, only a few fish were seen along the sandy beaches inside the lagoon; consequently, seining operations were not attempted. During the second visit, scattered schools of fish thought to be bonefish (*Albula vulpes*) and mullet were seen from the bait skiff in deep water along the southeast shore, but their location precluded seining.

These observations suggest that bait species suitable for use as supplemental live bait are available in the lagoon at Fanning Island; however, the surveys were not comprehensive enough to permit any conclusions as to the relative abundance of these stocks in various places in the lagoon, nor their availability to standard bait-fishing methods.

Christmas Island

This low coral island lies about 152 miles southeast of Fanning and 105 miles above the Equator. It is reported to be the largest coral island in the Pacific, having an estimated total area of 160 square miles. A large, shallow lagoon is located in the western part of the island, and the area also is dotted with small islets and brackish or salt-water lakes. The entrance to the lagoon, located on the

west side, is navigable by small boats, but caution must be exercised because of numerous coral heads. Suitable anchorage is available outside the main channel entrance to the lagoon.

A preliminary survey of the bait-fish resources of the area was made during a visit to the island by the *Hugh M. Smith* on October 31, 1950. Large quantities of bonefish and scattered schools of mullet were reported as occurring inside the lagoon, extending from the channel entrance to a distance of about 3 miles along the west and north shores. On a second visit to the area by the same vessel on June 8, 1951, a total of 52 buckets of thick-lip mullet (*Crenimugil crenilabis*), together with a few golden goatfish, were captured in six sets of a 40-fathom beach seine along the north shore of the lagoon. The hasty nature of these baiting operations did not permit observations in other parts of the lagoon.

The water area occupied by the lagoon at Christmas Island makes the island potentially the most important bait-fish source in the entire Line Island chain. However, before definite conclusions on the presence and abundance of the bait stocks in this area could be reached, it would be necessary to conduct extensive observations and baiting operations over the entire lagoon. A record that needs further investigation is the occurrence of the Hawaiian silversides (or a closely related species) in the lagoon. This is the only island in the Line chain from which this fish is recorded, and knowledge of its relative abundance throughout the year would be desirable.

Phoenix Islands

The Phoenix Islands comprise a group of eight islands lying about 500 miles northwestward of the Ellice Islands, below the Equator. All islands in the group are low and of coral formation. With the exception of Gardner, Hull, and Sydney, the islands are almost bare of vegetation. Only two islands in the Phoenix group, Canton and Hull, are of any importance as potential bait grounds. Gardner Island has an extensive lagoon, but because of the extremely dangerous passage into the lagoon, this area cannot be considered practicable as a baiting ground. The group is administered as part of the Crown Colony of the Gilbert and Ellice Islands and a resident officer is stationed on Canton.

Canton Island

Canton is the largest and most northerly of the Phoenix Islands. It is a triangular atoll located about 1,660 miles southwest of Honolulu. The east side of the island is approximately 9 miles long in a southeast-northwest direction, and the shorter lee side is about 4 miles in a north-

south direction. The atoll consists of a narrow strip of land enclosing a large lagoon. The land is unbroken except for two channels into the lagoon on the west side. The larger of these provides entrance for large vessels, and a coral-slab pier located just inside this passage offers excellent mooring facilities. Canton Island is administered jointly by the United States and Great Britain.

An initial survey of the bait resources of the lagoon was made by the senior author in June 1949 and the findings published (June 1950). The black-fin mullet and the thick-lip mullet were reported as the most abundant bait fishes in the lagoon. Small round herring, mountain bass, and goatfish also were in evidence in considerable quantities along the sandy beaches fringing the inside of the lagoon.

Bait-fishing activities at the island included three visits by the *Hugh M. Smith*, February 10, and July 13 to 15, 1950, and June 14 to 17, 1951; the *Henry O'Malley* visited the island during the period August 2 to 20, 1950. On the first baiting attempt by the *Hugh M. Smith*, 85 buckets of black-fin and blue-tail mullet were captured over the sand beaches along the west shore of the lagoon, and on the second visit 45 buckets of the same species were captured in the same locality. Because large quantities of bait were not required at the time, the fishing effort was not intensive. Two sets of a 40-fathom beach seine were required to capture the respective quantities of bait on these occasions. On the third bait-fishing trip to the island by the *Hugh M. Smith*, 256 buckets of black-fin and blue-tail mullet and golden goatfish were captured during 3 days of seining along the west and northwest shores of the lagoon. Observations indicated that mullet and other small fishes appeared to be much less abundant in the lagoon than on previous visits to the area. The baiting operations conducted during the *Henry O'Malley*'s visit yielded a total of 206 buckets of bait, consisting primarily of goatfish and mullet captured during 5 days of seining along the sandy beaches of the lagoon.

The observations and bait fishing carried on at intervals over a 2-year period indicate that the bait stocks present in the lagoon at Canton Island are composed of fishes which are considered only fair as tuna bait. Furthermore, the stocks of mullet show fluctuations in their apparent abundance at different times of the year. It may be concluded that goatfish and several species of mullet are present in the lagoon in sufficient numbers to provide limited supplemental bait supplies for clipper operations, but that this area should not be considered a large-scale baiting ground.

Hull Island

The island is a rectangular atoll, approximately 5 miles long and 2½ miles wide. It consists of a narrow land rim which surrounds

a shallow lagoon. The land rim is broken on the north and south sides by several very narrow, shallow passages which lead into the lagoon. The atoll is surrounded by a fringing reef. There is no harbor, but suitable anchorage may be found off the west side of the island.

Four visits to the island in search of tuna bait were made by vessels of the Pacific Oceanic Fishery Investigations during 1950 and 1951. On each occasion several species of mullet were observed in varying abundance along the northwest, southwest, and southeast beaches of the lagoon. These fish were not present in sufficient quantities to make seining attempts practicable, and it is doubtful that suitable bait fishes occur in sufficient abundance at any time to make seining operations feasible. Before definite conclusions could be reached it would be necessary to make extended observations throughout the year and over the entire lagoon.

Conclusions

The stocks of bait fish in the island waters of the central Pacific Ocean are an important element in the development and exploitation of the tuna fisheries of this region. It has been pointed out that the commercial skipjack fishery established in the Hawaiian Islands depends to a large extent upon a single bait species. Because of the limited availability of this and several other less-important bait fishes in Hawaiian waters, an investigation of other potential bait supplies which might be utilized for exploring the tuna stocks of the region was initiated as part of the research program of the Pacific Oceanic Fishery Investigations. Based on observations and the results of bait fishing at various islands and reef areas in the central Pacific region over the 2-year period, June 1949 through June 1951, certain tentative conclusions regarding the tuna-bait resources may be given.

The major Hawaiian Islands furnish enough bait fish to support a sizeable skipjack fishery. The Hawaiian anchovy, or nehu, accounts for about 95 percent of the bait used. It is doubtful that the present bait stocks could support a marked increase in fishing pressure, at least during the active skipjack season from April through October.

The Leeward Islands appear to be the most promising source of suitable live bait for pole-and-line tuna fishing. Of these, the Midway Islands are most noteworthy. From the results of the *Oregon's* explorations, it seems likely that French Frigate Shoal also supports important quantities of bait fishes, but until we understand the factors responsible for the apparent fluctuations of their availability, this area cannot be regarded as a dependable bait source. Pearl and Hermes Reef and Laysan and Lisianski Islands offer limited quantities

of bait, but the results of our observations indicate that these areas must be considered of minor importance.

The most common bait-fish species at the Midway Islands are the mountain bass, Hawaiian silversides, golden goatfish, and small round herring. At French Frigate Shoal the Hawaiian silversides is the most important species. In addition to the Hawaiian silversides, mountain bass and small round herring occur at Laysan and Lisianski Islands and Pearl and Hermes Reef.

Mountain bass, Hawaiian silversides, and golden goatfish are excellent bait species, as they show good survival qualities in the bait tanks and are attractive to yellowfin tuna and skipjack. The problems of mortality arising from the capture and subsequent handling of small round herring, however, would have to be solved before this desirable bait fish could be successfully adapted to long-distance transportation in bait tanks.

Because of the limited habitats available to shore-dwelling fishes, it is doubtful that the Leeward Islands support bait in sufficient quantities for extended clipper operations. On the other hand, it may be stated with some degree of confidence that the available bait stocks in this area would support the profitable operation of a sizeable fleet of small fishing vessels like those employed in the live-bait skipjack fishery in Hawaii.

Johnston Island appears to be of very little importance as a baiting ground.

Of the northern Line Islands, Christmas Island probably is the only baiting ground of consequence because of its vast lagoon area. Until more information is obtained concerning the distribution of the various fish species within the lagoon and their relative abundance in different areas, conclusions as to the availability of these species from the standpoint of commercial operations are not possible. A preliminary survey of Palmyra Island indicated some species of bait fish present in a suitable amount to augment bait supplies. Subsequent observations have failed to show the same abundance of bait species. Fanning Island has been only examined briefly and shows little promise of substantial bait resources.

Canton Island is the most likely source of bait in the Phoenix Islands; however, the black-fin mullet, blue-tail mullet, and the golden goatfish appear to be the only fishes present in sufficient quantities to be considered important. The lagoon at Canton is difficult to navigate because of extensive coral reefs, thereby limiting practical baiting operations to the shores along the west and northwest sides. The area probably should be considered as a possible source for supplemental bait but should not be relied on as a substantial baiting ground. During four visits to Hull Island no bait fish were seen in

sufficient quantities to make seining practical; however, only partial examinations of the rather extensive lagoon were made.

Most of the islands and reef areas in the central Pacific region offer bait stocks which are available for limited supplies of live bait for pole-and-line tuna fishing. These stocks, for the most part, are of limited use to small fishing vessels, and they do not represent sufficient supplies for clipper-type fishing vessels.

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